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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/509,935	08/19/2005	Serdar Sariciftci	15626-0011US1 / KTA-002	4312

26161 7590 05/10/2010
FISH & RICHARDSON PC
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER	
BERDICHEVSKY, MIRIAM	

ART UNIT	PAPER NUMBER
1795	

NOTIFICATION DATE	DELIVERY MODE
05/10/2010	ELECTRONIC

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BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte SERDAR SARICIFTCI, ERHARD GLOETZL, PATRICK DENK,
ROMAN RITTBERGER, and FRANZ PADINGER,

Appellants.

Appeal 2010-001296
Application 10/509,935
Technology Center 1700

Decided: May 6, 2010

Before SALLY GARDNER LANE, RICHARD TORCZON, and
MICHAEL P. TIERNEY, *Administrative Patent Judges*.

LANE, *Administrative Patent Judge*.

DECISION ON APPEAL

I. STATEMENT OF THE CASE

The appeal, under 35 U.S.C. § 134(a), is from a Final Rejection of Appellants' claims 1-10, 12-19, and 22-24. Appellants cancelled claims 11, 20, and 21. (App. Br. 1). We have jurisdiction under 35 U.S.C. § 6(b). We affirm.

Appellants' application is directed to treatment of photovoltaic cells. (Spec. 1).

The Examiner relied on the following publications:

- Cravino and Sariciftci, *Double-cable Polymers for Fullerene Based Organic Optoelectronic Applications*, 12 J. Materials Chemistry, 1931-43 (2002) ("Cravino");

- Dittmer et al., *Electron Trapping in Dye/Polymer Blend Photovoltaic Cells*, 12 Advanced Materials, 1270-74 (2000) ("Dittmer");

- Gebeyehu et al., *Characterization of Large Area Flexible Plastic Solar Cells Based on Conjugated Polymer/Fullerene Composites*," 1 Int'l J. Photoenergy, 1-5 (1999) ("Gebeyehu");

- Sentein et al., *Study of Orientation Induced Molecular Rectification in Polymer Films*," 9 Optical Materials, `316-22 (1998) ("Sentein"); and

- Zhao et al. "*A Calorimetric Study of the Phase Transitions in Poly(3-hexylthiophene)*," 36 Polymer, 2211-14 (1995) ("Zhao").

The Examiner rejected claims 1-10, 12-19, and 22-24 under 35 U.S.C. § 103(a) over Cravino, Sentein, Zhao, Dittmer, and Gebeyehu. Appellants argued for the separate patentability of the independent claims 1, 10, 19, and 24 and many of the dependent claims, which will be discussed below.

II. FINDINGS OF FACT

1. Appellants' claim 1 recites:

> A method for the post-treatment of a photovoltaic cell, the photovoltaic cell comprising a photoactive layer and two metal electrodes,
>
> the photoactive layer comprising
>
> a conjugated polymer and
>
> a fullerene, and
>
> the two metal electrodes provided on either side of the photoactive layer,
>
> the method comprising:
>
> subjecting the photovoltaic cell to heat treatment above a glass transition temperature of the conjugated polymer for a predetermined treatment time, the heat treatment of the photovoltaic cell being carried out for at least a portion of the treatment time under the influence of an electric field induced by a field voltage applied to the electrodes of the photovoltaic cell and exceeding a no-load voltage thereof;
>
> wherein the fullerene is a compound different from the conjugated polymer.

(App. Br. 34, Claims App'x).

2. Cravino depicts a photovoltaic device with metal electrodes (anode and cathode) on either side of a photoactive layer comprising a conjugated polymer and a fullerene. (Cravino Fig. 1, p. 1931, right. col.).

3. Appellants admit in their specification that photoactive layers made from conjugated polymers and fullerenes were known in the art. (Spec., translation p. 1).

4. Cravino does not teach treating a photovoltaic cell with heat under the influence of an electric field.

5. Sentein teaches enhancing the efficiency of polymeric semiconductors, by orienting the polymer to induce one-way movement of

electrons, called "molecular rectification." (Sentein abstract and section 1, paragraph 1).

6. Sentein teaches that molecular rectification is useful for improving the efficiency of photovoltaic cells. (Sentein section 5, paragraph 1).

7. Sentein teaches that molecular rectification can be obtained in single polymer diode-like molecules by applying a static electric field through the polymer, while heating it to *near* the glass transition temperature. (Sentein section 1, paragraph 2).

8. Gebeyehu discusses solar cells made of conjugated polymer/fullerene composites and teaches that charge transport between the conjugated polymers and the fullerenes is "favorably tuned by electric field," wherein the electric field allows proper movement of electrons. (Gebeyehu p. 2, right col.).

9. Neither Sentein nor Gebeyehu teaches heating to *above* the glass transition temperature.

10. Appellants admit in their specification that those of skill in the art knew that crystallization increases above the glass transition temperature and that subjecting photovoltaic cells to post-treatment with heat at 60 to 150 °C for one hour increases efficiency, even if only minimally. (Spec. translation p. 1).

11. Zhao teaches that crystallinity in P3HT is dependent on temperature and that slower crystal formation occurs at temperatures *above* the glass transition temperature of a polymer. (Zhao p. 2213, left col.).

12. Dittmer teaches that slower crystallization of the polymer P3HT, which is provided in Appellants' specification as being within the

scope of the claimed polymer (Spec. translation p. 5), leads to increased electron mobility (Dittmer p. 1273, left col.), which increases the efficiency of photovoltaic cells.

13. Appellants' claim 10 recites:

> A method of treating a photovoltaic cell, the method comprising:
> heating the photovoltaic cell for a period of time; and simultaneously subjecting the photovoltaic cell to an electric field,
> wherein the photovoltaic cell comprises:
> a first electrode;
> a second electrode; and
> a photoactive layer between the first and second electrodes,
> the photoactive layer comprising an electron donor and an electron acceptor, the electron acceptor being a compound different from the electron donor.

(App. Br. 35, Claims App'x).

14. Appellants' claim 19 recites:

> A method of treating a photovoltaic cell, the method comprising:
> heating the photovoltaic cell for between 2 and 8 minutes; and
> simultaneously subjecting the photovoltaic cell to an electric field,
> wherein the photovoltaic cell comprises:
> a first electrode;
> a second electrode; and
> a photoactive layer between the first and second electrodes,
> the photoactive layer comprising an electron donor and an electron acceptor that is different from the electron donor;
> the photoactive layer is heated to above a glass transition temperature of the electron donor;

> the electric field is formed by applying a field voltage to the first and second electrodes; and
>
> the electric field exceeds a no-load voltage of the photovoltaic cell.

(App. Br. 36-37, Claims App'x).

15. Sentein provides Figure 6 with data on the degree of orientation as a function of time, wherein with more time, more rectification behavior was seen. (Sentein, p. 319, Fig. 6).

16. Appellants' claim 24 recites:

> A method of treating a photovoltaic cell, the method comprising:
>
> heating the photovoltaic cell for a period of time; and
>
> simultaneously injecting charge carriers into the photovoltaic cell,
>
> wherein the photovoltaic cell comprises:
>
> a first electrode;
>
> a second electrode; and
>
> a photoactive layer between the first and second electrodes,
>
> the photoactive layer comprising an electron donor and an electron acceptor that is different from the electron donor;
>
> the photoactive layer is heated to above a glass transition temperature of the electron donor; and
>
> the charge carriers are injected into the photovoltaic cell via at least one electrode selected from the group consisting of the first electrode and the second electrode.

(App. Br. 37, Claims App'x).

III. ISSUE

Would those of skill in the art have modified photovoltaic cells comprising polymer and fullerene by applying an electric field and heating a single polymer semiconductor diode, as taught in Sentein?

Would those of skill in the art have understood from Zhao and Dittmer that temperatures above the glass transition temperature would increase the efficiency of a photovoltaic cell comprising polymer and fullerene?

IV. ANALYSIS

Claim 1

Appellants' claim 1 recites a method of treating a photovoltaic cell. (FF 1[1]; App. Br. 34, Claims App'x). Appellants admit in their specification (FF 3; Spec. translation p. 1), and Cravino shows (FF 2; Cravino Fig. 1, p. 1931, right col.), that the kind of photovoltaic cell treated in the method of claim 1, one comprising a conjugated polymer, a fullerene, and two metal electrodes, was known in the art. Cravino does not teach the claimed treatment for these photovoltaic cells. (FF 4).

Sentein discusses improving polymer photovoltaic cells by orienting the polymer to induce one-way movement of electrons, called "molecular rectification." (FF 5; Sentein abstract and section 1, paragraph 1). Molecular rectification is useful for building efficient photovoltaic cells. (FF 6; Sentein section 5, paragraph 1). In the method taught by Sentein, an electric field is applied to the polymer, while it is also heated near the glass transition temperature. (FF 7; Sentein section 1, paragraph 2).

Like Sentein, Gebeyehu teaches using an electric field to achieve "favorable tuning" with greater electron movement in polymer/fullerene photovoltaic cells. (FF 8; Gebeyehu p. 2, right col.).

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[1] FF indicates a Finding of Fact.

Sentein does not teach using a temperature *above* the glass transition temperature, but only "near" the glass transition temperature. (FF 9). Zhao and Dittmer teach that slower crystal formation occurs at higher temperatures in polymers within the scope of Appellants' claimed photovoltaic cell (FF 11; Zhao p. 2213, left col.) and that slower crystallization leads to increased electron movement within the polymer (FF 12; Dittmer p. 1273, left col.), allowing for higher efficiency. This reflects what Appellants admit in their specification – that it was known that crystallization increases above the glass transition temperature and that efficiency of photovoltaic cells treated at this temperature is increased, even if only minimally. (FF 10; Spec. translation p. 1).

Those of skill in the art would have recognized that treating a polymer/fullerene photovoltaic cell with an electric field, while heating it, would improve electron movement from the teachings of Sentein, Gebeyehu, Zhao, and Dittmer.

> When a work is available in one field of endeavor, design incentives and other market forces can prompt variations of it, either in the same field or a different one. If a person of ordinary skill can implement a predictable variation, § 103 likely bars its patentability. For the same reason, if a technique has been used to improve one device, and a person of ordinary skill in the art would recognize that it would improve similar devices in the same way, using the technique is obvious unless its actual application is beyond his or her skill.

KSR Int'l Co. v. Teleflex, Inc., 550 U.S. 398, 417 (2007).

Appellants argue that those of skill in the art would not have modified the photovoltaic cells of Cravino with the method taught in Sentein because Sentein teaches semiconductors with a single polymer, not photovoltaic cells

that comprise polymer and fullerene. (App. Br. 8). Appellants argue that Sentein specifically contrasts the junctions of organic semiconductors like the polymer/fullerene photovoltaic cells (those with "p-n junctions") of Cravino (*see* FF 2; Cravino Fig. 1, p. 1931, right col.), with the polymer semiconductors Sentein treats with an electric field and heat (*see* Sentein section 1, paragraph 1). (App. Br. 8). According to Appellants, Sentein teaches using an electric field to orient a junction formed of a single, polar compound with a donor/transmitter/acceptor structure, not a polymer/fullerene photovoltaic cell. (*Id.*). Appellants argue that because Cravino fails to discuss treating polymer/fullerene material, those of skill in the art would not have found it obvious to modify the cells of Cravino with the process taught in Sentein. (*Id.*).

We do not read Sentein to be as limited as Appellants argue. Sentein does not preclude applying an electric field and heating to p-n junctions. Instead, Sentein provides an alternative to p-n junctions. (*See* Sentein section 1, paragraphs 1 and 2). It would have been reasonable for those in the art to treat p-n junction semiconductors, including polymer/fullerene photovoltaic cells, because, as the Examiner found, both the polar diode molecules of Sentein and the polymer/fullerenes p-n junctions of Cravino, have a net charge that enables control via an electric field. (Ans. 16). Appellants do not dispute the Examiner's finding or provide evidence that the molecules of Cravino have other properties that would make them resistant to orienting under an electric field with heat. Accordingly, we agree with the Examiner that Sentein provides a general teaching to apply an electric field with heat to orient polymeric material and that those of skill in the art would consider this a way to improve the efficiency of the

polymer/fullerene photovoltaic cell of Cravino. *See KSR Int'l Co. v. Teleflex, Inc.*, 550 U.S. 398, 421 (2007) ("Where there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has a good reason to pursue the known options within his or her technical grasp. If this leads to the anticipated success, it is likely the product not of innovation but or ordinary skill and common sense. In that instance the fact that a combination was obvious to try might show that it was obvious under § 103.").

Appellants also argue that Zhao does not expressly teach heating a polymer above its glass transition temperature to obtain enhanced crystallization. (App. Br. 9). However, Dittmer supports the teaching in Zhao of a higher temperature by explaining the benefits of slower crystallization. (App. Br. 10). The record supports the Examiner's finding that the combination of Zhao and Dittmer would indicate to those of skill in the art that enhanced crystallization by heating to above the glass transition temperature improves electron movement in polymer material. (*See* Ans. 17).

Appellants argue further that Gebeyehu teaches applying an electric field during the use of a photovoltaic cell, not during its preparation. (App. Br. 10). Appellants do not provide a definition of the claim term "post-treatment" in their specification. "During examination, 'claims ... are to be given their broadest reasonable interpretation consistent with the specification, and ... claim language should be read in light of the specification as it would be interpreted by one of ordinary skill in the art.'" *In re American Academy of Sci. Tech Center*, 367 F.3d 1359, 1364 (Fed. Cir. 2004) (quoting *In re Bond*, 910 F.2d 831, 833 (Fed. Cir. 1990). The

broadest reasonable interpretation of the claim term "post-treatment" would encompass a treatment when the solar cell is in use. Thus, the teaching of Gebeyehu regarding application of an electric field is relevant to the claimed method.

Appellants argue that Sentein does not expressly teach applying a field voltage that exceeds the no-load voltage, but that the Examiner relies on inherent properties of the teachings of Sentein. (App. Br. 10-11). The Examiner explains that a "no-load voltage" is a voltage of more than zero. (Ans. 19). Appellants do not dispute this or provide evidence to show that a "no-load voltage" is any specific voltage above zero. Sentein teaches a voltage of 5-20 V (Sentein, section 3, paragraph 3). Thus, considering the broadest reasonable interpretation of the claim term, *see Am. Acad.*, 367 F.3d at 1364, Sentein teaches the claimed voltage.

Appellants have not persuaded us that the Examiner erred in rejecting claim 1 under 35 U.S.C. § 103(a).

Dependent claims 10, 19, and 24

Appellants argue for the separate patentability of each of the independent claims.

Independent claim 10 recites a method of treating a photovoltaic cell similar to that of claim 1, but the cell is heated "for a period of time," unlimited by a temperature above the glass transition temperature, and is subjected to an electric field of unspecified voltage. (FF 13; App. Br. 36-37, Claims App'x). Appellants' arguments against the rejection of claim 10 are the same as those against the rejection of claim 1. Because we find the arguments against the rejection of claim 1 unpersuasive, for the reasons

provided above, we are also not persuaded that the rejection of claim 10 was made in error.

Independent claim 19 recites a method of treating a photovoltaic cell that is also similar to that recited in claim 1, but the cell is heated "for between 2 and 8 minutes." (FF 14; App. Br. 36-37, Claims App'x). Appellants argue that those of skill in the art would not have known that the time of heating is a result effective variable and, thus, would not have found the method to be obvious. (App. Br. 25). Sentein provides data showing that orientation of the polymer with heat treatment is a function of time, with greater rectification behavior at longer times. (FF 15; Sentein, p. 319, Fig. 6). Thus, the record supports the Examiner's finding that those of skill in the art would have considered time to be a result effective variable in treatment of photovoltaic cells. Appellants have not provided evidence that the claimed time period of between 2 and 8 minutes is unexpectedly good. Accordingly, it is likelier that those of skill in the art would have known to adjust heating time to optimize results. *See In re Boesch*, 617 F.2d 272, 276 (CCPA 1980) ("discovery of an optimum value of a result effective variable in a known process is ordinarily within the skill of the art. . . . It is well settled that a prima facie case of obviousness may be rebutted 'where the results of optimizing a variable, which was known to be result effective, (are) unexpectedly good.'" (quoting *In re Antonie*, 559 F.2d 618, 620 (CCPA 1977)).

Appellants' other arguments against the rejection of claim 19 are the same as those against the rejection of claim 1. Because we find the arguments against the rejection of claim 1 unpersuasive, for the reasons

provided above, we are also not persuaded that the rejection of claim 19 was made in error.

Finally, independent claim 24 recites a method of treating a photovoltaic cell wherein "charge carriers are injected into the photovoltaic cell via at least one electrode selected from the group consisting of the first electrode and the second electrode." (FF 16; App. Br. 37, Claims App'x). Appellants argue that the Examiner has not provided a basis in fact for the finding that charge carriers are inherently injected when an electric field is applied. (App. Br. 32). The Examiner explains that when a current is applied, electrons, which are the carriers, flow from an anode to a cathode – the electrodes of the claimed photovoltaic cell. (Ans. 52-53). Appellants provide no argument or evidence that this phrase in claim 24 would be interpreted differently by those of skill in the art. It is likelier that the feature is inherently taught in the prior art.

Appellants' other arguments against the rejection of claim 24 are the same as those against the rejection of claim 1. Because we find the arguments against the rejection of claim 1 unpersuasive, for the reasons provided above, we are also not persuaded that the rejection of claim 24 was made in error.

In conclusion, Appellants have not persuaded us that the Examiner erred in rejecting claims 10, 19, and 24 under 35 U.S.C. § 103(a).

Dependent claims

Appellants argued for the separate patentability of claims 2, 3, 12, 14-16, and 22. (App. Br. 11-12, 18, 19-20, and 27). Claims 2 and 3, which depend on claim 1, claims 12 and 14-16, which ultimately depend on claim 10, and claim 22, which depends on claim 19, each limit the amount of

voltage of the electric field. Specifically, claims 2, 15, and 22 limit the electric field to exceeding the no-load voltage by at least 1 V; claims 3 and 16 limit the electric field to between 2.5 and 3V; and claims 12 and 14 limits the electric field to exceeding a no-load voltage, but not by a specified amount. (*See* App. Br. 34-37, Claims App'x).

Sentein provides Figure 7, which shows a relationship between molecular order and voltage. (Sentein p. 320). Thus, those of skill in the art would have considered voltage to be a result effective variable for treatments of the polymers in photovoltaic cells. Appellants have not provided evidence that the claimed time voltages are unexpectedly good. It is likelier that those of skill in the art would have varied the voltage to optimize results. *See Boesch*, 617 F.2d at 276.

Appellants argued for the separate patentability of claims 4-6, 7-9, 17, 18, and 23. (App. Br. 13, 21, and 27-28). Claims 4-6 and 7-9, which depend from claim 1, claims 17 and 18, which ultimately depend from claim 10, and claim 23, which depends from claim 19, each limit the amount of time that the cell is heated. Claims 4-6 and 17 limit the time to between 2 and 8 minutes, while claims 7-9, 18, and 23 limit the time to between 4 and 5 minutes. (*See* App. Br. 34-37, Claims App'x). As explained above, in regard to claim 19, Sentein provides data showing time is a result effective variable in treatment of photovoltaic cells. Because Appellants have not provided evidence that the claimed times are unexpectedly good, it is likelier that those of skill in the art would have varied the time to optimize results. *See Boesch*, 617 F.2d at 276.

Finally, Appellants argue separately for the patentability of claim 13 (App. Br. 18-19), which requires the electric field to be formed by applying

a field voltage to the first and second electrodes. (App. Br. 36, Claims App'x). Appellants' arguments against the rejection of claim 13 are the same as those against the rejection of claim 1. These arguments are unpersuasive for the reasons given above.

In conclusion, Appellants have not persuaded us the Examiner erred in rejecting dependent claims 2-9, 12-18, 22 and 23 under 35 U.S.C. § 103(a).

V. ORDER

Upon consideration of the record and for the reasons given, the rejection of claims 1-10, 12-19, and 22-24 under 35 U.S.C. § 103(a) over Cravino, Sentein, Zhao, Dittmer, and Gebeyehu is AFFIRMED.

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv)(2007).

AFFIRMED

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